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Indian Standard

CODE OF PRACTICE FOR CORROSION PROTECTION IN FERTILIZER PLANTS

PART 1 PHOSPHORIC ACID PLANT

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INDIAN STANDARDS INSTITUTION
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PART 1 PHOSPHORIC ACID PLANT

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CODE OF PRACTICE FOR CORROSION PROTECTION IN FERTILIZER PLANTS

PART 1 PHOSPHORIC ACID PLANT

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 15 January 1986, after the draft finalized by the Corrosion Protection Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 During the manufacture of phosphoric acid by wet process, common engineering materials suffer corrosion and erosion occurs simultaneously in the system due to the action of sulphuric acid — phosphoric acid mixture, rock phosphate and gypsum slurry. In addition silicon, fluorides and sulphates are the main corrosion stimulating contaminants in the system.

0.3 This code has been prepared after studies having been made on various types of materials, specially with stainless steels of designations 04Cr17Ni12Mo2 and other stainless steels generally available. Agitator blades in the attack tank made from these steels have been reported to have failed in about three months period. Therefore, this standard recommends the use of high alloy steels with high chromium and nickel contents ranging from chromium 27 to nickel 31 percent content for most of the components.

0.4 This code is one of the series of standards being prepared to cover the various process plants in the fertilizer plants. This standard has been prepared to provide the guidance for corrosion protection measures to be taken in the manufacture and design of phosphoric acid plants manufactured by wet process

1. SCOPE

1.1 This code outlines the corrosion principle in the phosphoric acid plants of the fertilizer industry by wet process and gives recommendations for materials of construction for various sections of the plant in order to minimize corrosion.

1.2 Plants producing phosphoric acid by thermal process are not covered by the standard as the magnitude of corrosion in such plants is comparatively low.

2. CORROSION PROCESS IN PHOSPHORIC ACID PLANT

2.1 The metallic equipment in the manufacture of wet process phosphoric acid suffers severe corrosion and erosion. Corrosion and erosion occur simultaneously in the system due to the action of the sulphuric-phosphoric acid mixture, rock phosphate, gypsum slurry, and silica (silica has a marked effect on the erosive character of the slurry). The erosive character of the rock phosphate, however, cannot be predicted on the basis of total silica content because the nature and preparation of the various types of silica present vary from source to source. Fluorine is derived from the rock phosphate. During acidulation, hydrofluoric acid is produced which is very reactive and combines immediately with silica to form silicon tetrafluoride. When there is insufficient silica, free hydrofluoric acid is liberated. Silicon tetrafluoride is further converted to hydrofluosilicic acid and flurosilicates. Chloride has its origin mainly from rock, while sulphate originates from sulphuric acid.

3. PHOSPHORIC ACID MANUFACTURING PROCESS

3.1 General — Phosphoric acid can be manufactured by four different processes in the wet process technology. These processes are:

a) Conventional dihydrate process,
b) Anhydride process,
c) Hemihydrate dihydrate process, and
d) Dihydrate hemihydrate process.

3.2 Principle — All the four processes consist of reacting rock phosphate with sulphuric acid-phosphoric acid mixture followed by filtration of the calcium sulphate from the reaction mixture in the form of calcium sulphate crystals ($CaSO_4.2H_2O$) or simply as anhydrous calcium sulphate or converting the hemihydrate crystals obtained into dihydrate and then filtering it or conversion of dihydrate crystals obtained into hemihydrate. The filtered phosphoric acid is further concentrated to 54 percent concentration for converting it into phosphatic fertilizers.

3.3 Process — The process condition consists of feeding ground rock phosphate, sulphuric acid and return phosphoric acid simultaneously and continuously into an attack tank. The temperature of the system varies in the range of 70 to 90°C depending on the process route. The concentration and the rate of feed of sulphuric acid, phosphoric acid and ground rock phosphate varies with the process. About 80 to 90 percent

of the rock is decomposed in the attack tank and the resultant slurry flows over to the subsequent vessels where the reaction is completed. The choice of construction material for the different sections of the plant depends on the prevailing corrosive condition. The most critical areas are attack tanks, filter section and concentration unit. Pumps for circulating the process solution are subjected to very corrosive and erosive condition.

4. SELECTION OF MATERIALS OF CONSTRUCTION AND FABRICATION OF PLANT FOR MINIMIZING CORROSION

4.1 Attack Tank — The attack tank is fabricated by butt welding carbon steel plates conforming to IS : 2002-1982* or IS : 2041-1982†. All the interior welds shall be ground smooth with all sharp edges removed, corners ground to a minimum radius of 3 mm. The inner surfaces shall be lined with 5 mm thick calendered natural rubber sheet having a hardness of 45 to 60 IRHD. The rubber linings shall be spark tested at 15 kV before and after curing. The rubber lining may peel-off due to increase in operating temperatures. Adequate cooling arrangements shall be provided to ensure that the operating temperatures do not exceed the design values. The bottom and sides of the attack tank shall also be protected with carbon bricks, set in carbon filled furnace cement.

4.1.1 *Agitator Blades* — Agitator blades are prone to high degree of corrosion and erosion due to voilent agitation of reaction mixture. To provide a long life it is recommended that these blades shall be made of high alloy steels with following composition:

C	Cr	Ni	Mo	Cu
0·02	27·0	31·0	3·5	1·0

4.1.2 *Pumps* — Recirculating pumps and return acid feed pumps shall be made from high alloy cast steel grades 12 and 14 conforming to IS : 7806-1985‡.

4.2 Subsequent Vessels — These vessels are usually made of carbon steels conforming to IS : 2002-1982* or IS : 2041-1982†. These vessels shall also be lined with calendered natural rubber sheets of hardness ranging between 45 and 60 IRHD.

*Specification for steel plates for pressure vessels for intermediate and low temperature (*first revision*).

†Specification for steel plates for pressure vessels used at moderate and low temperature (*first revision*).

‡Martensitic and austenitic high alloy steel castings for high temperature service.

4.3 Filter Section — Filter and filter screens shall be made of high alloy steels having following chemical composition:

C	Cr	Ni	Mo	Cu
0·02	27·0	31·0	3·5	1·0

4.3.1 *Filter Pans* — Special stainless steels least susceptible to stress corrosion cracking are recommended to be used for construction of filter pans.

4.4 Pipings, Ducts and Scrubbers

4.4.1 *Pipings* — The piping for transfer of crude phosphoric acid from attack tank and subsequent vessels to the filtration units shall be made of steel and lined with vinylidene chloride. Natural rubber lining may also be used, but this may get softened due to entrapped organic floatation agents. Neoprene rubber can also be used with satisfactory results.

4.4.2 *Ducts* — The ducts shall be made of glass reinforced polyester fibre with the innermost reinforcing layer made of acrylic fibre to counter the attack of hydrofluoric acid on glass fibre.

4.4.3 *Scrubber* — The scrubber shall be made of natural rubber lined with inter-connecting piping of reinforced epoxy, vinylidene chloride or rubber lined steel pipes. High alloy steel pipes may also be used with advantage.

4.5 Evaporators — Evaporators shall be made of high corrosion and erosion resistance material. The recommended material shall have the following chemical composition:

C	Cr	Ni	Mo	Cu
0·02	27·0	31·0	3·5	1·0

The heat exchangers in the evaporator shall be made of impervious graphite tubes or blocks. However, for greater corrosion and erosion protection high chrome-nickel alloys of the above composition are recommended for the manufacturer of heat exchanger.

5. MAINTENANCE FOR CORROSION PREVENTION

5.1 Attack Tank — Due to matt surface of the rubber lining, gypsum in the slurry tends to adhere to the rubber lining forming a cake-like deposit. It is recommended that the plant may be shut down periodically for removal of the cake.

5.2 Filter Section — Filter pans shall be regularly washed to remove scales. For this purpose chlorine free water shall be used to avoid entraping of chlorides which may induce stress corrosion cracking under high mechanical load.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2